

Engineering Successful/Unsuccessful Program Participation's Impact on Future Student Success: A Propensity Score Analysis

Engineering Successful/Unsuccessful Program at Colorado State University

In the College of Engineering (EG) at Colorado State University (CSU), the Successful/Unsuccessful program was founded to support academic success of students during their transition into the first year of engineering. Motivated by similar programs at medical schools and at major engineering schools such as MIT and Caltech, the Successful/Unsuccessful program at CSU aims to reduce pressure associated with traditional grades during the first semester of higher education. The Successful/Unsuccessful program offers first-time freshmen the option of receiving pass-fail outcomes in lieu of traditional grades. This gives students the ability to control an aspect of their learning environment—the grading system—that is typically and exclusively within the purview of the faculty.

Purpose

This study compares student success among new freshmen who participate in the EG Successful/Unsuccessful program compared to those who do not. Additionally, this study focuses on understanding the differential impact of program participation on future student success for female and minority EG students compared to male and non-minority EG students. Student success is measured by second-fall retention (within college and within university), third-fall retention (within college and within university), and GPA (first-spring term and second-fall term).

Data

First-time, full-time freshmen from the FA10 through FA12 EG cohorts are included in this study. Table 1 displays the cohort sizes across program participation status. Program participation status is defined by students' self-selected status at the end of their first fall semester. EG students can opt into and out of first semester participation at any point prior to earning 60 credits, transferring out of CSU, or changing their major; however, for consistency this analysis tracks participation based on the student's status at the end of their first fall semester. For the three cohorts included in this study, program participation has grown 113% and the total EG freshman cohort size has grown about 30%. Overall the program serves approximately 43% of first-time, full-time EG students.

Table 1.

Count of Full-Time Freshmen by Cohort Term and Engineering Successful/Unsuccessful Program Participation				
	FA10	FA11	FA12	Total
Participant	138	223	294	655
Non-Participant	309	263	287	859
Total EG Cohort	447	486	581	1,514
Percent of Total in Program	31%	46%	51%	43%

The FA12 cohort has not had the opportunity to have their third-fall retention tracked (FA14 is their third fall semester); therefore, the analyses for this student success outcome are only completed among the FA10 and FA11 EG cohorts.

Demographics and Academics of Participants and Non-Participants

The following section describes the demographics and academic preparation of EG students. Table 2 displays the percent of students who are first generation, Pell grant recipients, minority students, Colorado residents, or females by program participation status. Additionally, table 2 also displays the average Math ACT score and CCE index score by participation status. Twenty-six of the students from the FA10 through FA12 EG cohorts (shown in table 1) do not have an index score and are excluded from the analyses included in this report. If a student did not take the ACT their SAT math score is converted to an ACT score. All students with an index score have an SAT or ACT score.

Table 2.

Descriptive Statistics for Engineering Successful/Unsuccessful Program Participation Populations			
	Participant (651)	Non-Participant (837)	
First Generation (%)	17.5	17.5	17.9
Pell Recipient (%)	15.4	15.4	16.9
Minority (%)	10.8	10.8	13.6
CO Resident (%)	73.7	73.7	77.3
Female (%)	22.1	22.1	25.9
Math ACT (average)	27.6	27.6	27.9
Index (average)*	122.4	122.4	124.2

* Indicates when the proportion or average is statistically different ($p < .01$) for participants compared to non-participants

Generally, program participants are very similar to non-program participants in terms of the demographics displayed in table 2. For instance, among the 651 program participants 17.5% are first generation compared to 17.9% of the 837 non-participants. There is a slight association ($p < .1$) between participation status and gender as well as participation status and minority status. Participants have smaller representation of females (22.1% compared to 25.9%) and minority students (10.8% compared to 13.6%) compared to non-participants. Participants do have a lower average index score compared to non-participants (122.4 and 124.2; respectively), but are similar in terms of their Math ACT score.

Table 3 displays percent of participants and non-participants by their EG major/department.

Table 3.

Major/Department Distributions for Engineering Successful/Unsuccessful Program Participation Populations			
	Participant (651)	Non-Participant (837)	
Chemical and Biological Engineering (%)*	6.9	6.9	11.8
Civil and Environmental Engineering (%)	20.1	20.1	20.1
Electrical and Computer Engineering (%)	9.2	9.2	11.6
Mechanical Engineering (%)	27.7	27.7	32.1
Biomedical Engineering (%)	11.7	11.7	8.7
Space Engineering or Engineering Science (%)	2.3	2.3	2.3
Engineering Open Option (%)*	22.1	22.1	13.4

* Indicates when the proportion of students in a major/department is statistically different ($p < .01$) for participants compared to non-participants

EG Successful/Unsuccessful program participants are more likely to be in the EG Open Option major compared to non-participants (22.1% and 13.4%; respectively) and they are less likely to be in in the Chemical and Biological EG department (6.9% and 11.8%; respectively). Otherwise the distributions by major/department are similar between program participants and non-participants.

Methodology

A propensity score analysis is used to estimate the treatment effect of program participation on future student success. This type of quasi-experimental analysis is necessary because students self-select (are not randomly assigned) to participate in the program, which introduces statistical bias to causal interpretations of multivariate regression models. Propensity score matching allows for a comparison of statistically similar groups (participants/non-participants) of students with the goal of understanding what the outcome would have been for a program participant if he/she had not participated in the program (the counterfactual outcome).

The propensity score approach uses a logistic regression model to calculate the probability that a student will be in the EG Successful/Unsuccessful program based on a variety of academic and demographic variables. Demographically program participation is estimated by a student's minority, first-generation, and Pell recipient status as well as their gender and residency. In terms of academics, program participation is estimated by their CCHE index score, Math ACT score and their original major within EG. Since this study focuses on determining if any differential effects exist for minority and female students the propensity score model is run for each subgroup of students (minority, non-minority, male, and female). The appendix contains the logistic regression coefficients for the models that predicted program participation across the four different subgroups used in this study. Appendix A is for the models that predicted participation among the FA10 through FA12 cohorts (2nd year retention and GPA) and appendix B is for the models that predicted participation among the FA10 and FA11 cohorts (3rd year retention).

The probability of a student being in the program is his/her propensity score. The propensity score is then used to balance the dataset. This means that program participants are matched (based on having a similar propensity score) to one unique non-program participant. In order for a program participant to be included they must have a propensity score that is similar (within a quarter of a standard deviation of the sub-group's propensity score) to a non-program participant. Some program participants' propensity to be in the program is so different then all of the non-program participants that they are excluded from the analysis because there isn't a comparable student to match them with. The premise of this approach is that the matched groups are similar in terms of characteristics that influence program participation; therefore, differences in the measures of student success between the matched groups can be attributed to the program's treatment effect rather than differences in student demographics or academics.

Propensity Score Results

This section reviews the student success outcomes (second-fall retention, third-fall retention, and GPA) by participation status and sub-group before and after the propensity score adjustments.

2nd Fall Retention

Analyses of second-fall retention include EG students from the FA10 through FA12 cohorts.

Within University 2nd Fall Retention

Table 5 displays the within university second-fall retention rates for participants and non-participants by student subgroup prior to the propensity score adjustment.

Table 5.

Unadjusted within University 2 nd Fall Retention Rate Comparisons, Successful/Unsuccessful Program vs. Non-Participants				
	Females	Males	Minority	Non-Minority
Successful/Unsuccessful Program Participants	89.6%	91.5%	81.4%	92.3%
Non-Participants	90.3%	88.2%	92.1%	88.2%
Difference	-0.7%	3.3%	-10.7%	4.0%
N for Participants / Non-Participants	144 \ 217	507 \ 620	70 \ 114	581 \ 723

As shown in table 5, male and non-minority program participants have slightly higher second-fall retention rates compared to their non-program peers; however, female program participants have a slightly lower second-fall retention rate compared to the non-program students and minority participants have a substantially lower second-fall retention rate compared to minority non-program students.

Table 6 displays the propensity score adjusted within university second-fall retention rates. These are the retention rates only among students who are statistically selected to be in the participant and non-participant comparison groups.

Table 6.

Propensity Score Adjusted within University 2 nd Fall Retention Rate Comparisons, Successful/Unsuccessful Program vs. Non-Participants				
	Females	Males	Minority	Non-Minority
Successful/Unsuccessful Program Participants	89.4%	91.6%	80.6%	92.3%
Non-Participants	87.1%	88.5%	90.3%	88.6%
Difference ^{1,2}	2.3% (4.0%)	3.1% (2.0%)	-9.7% (6.3%)	3.7% (1.8%)
N for Participants / Non-Participants	132 \ 132	451 \ 451	62 \ 62	535 \ 535
Additional Students Retained within University	NA	NA	NA	NA

¹Average treatment effect among the treated, with standard error in parentheses

² * $p < 0.01$

Among the propensity score matched samples female, males, and non-minority program participants have slightly higher within second-fall university retention rates compared to non-program peers. Minority student program participants have a lower within university second-fall retention rate compared to minority non-participants. However, none of these differences are large enough to be attributed to a treatment effect of the program. There is not a negative or positive impact of program participation on within university second-fall retention for any subgroup of students.

Please note the changes in sample size among the propensity score adjusted data. For instance, there are 144 female program participants but only 132 have a propensity score that is similar to non-program participants. These 132 female participants are matched to 132 similar non-participants to conduct the analysis.

Within College 2nd Fall Retention

Table 7 displays the within college second-fall retention rates for participants and non-participants by student subgroup prior to the propensity score adjustment.

Table 7.

Unadjusted within College 2 nd Fall Retention Rate Comparisons, Successful/Unsuccessful Program vs. Non-Participants				
	Females	Males	Minority	Non-Minority
Successful/Unsuccessful Program Participants	69.4%	76.3%	70.0%	75.4%
Non-Participants	62.2%	68.1%	67.5%	66.4%
Difference	7.2%	8.3%	2.5%	9.0%
N for Participants / Non-Participants	144 \ 217	507 \ 620	70 \ 114	581 \ 723

Across all of the student subgroups participants have higher within college second-fall retention rates compared to non-participants.

Table 8 shows the retention rates among the propensity score adjusted data.

Table 8.

Propensity Score Adjusted within College 2 nd Fall Retention Rate Comparisons, Successful/Unsuccessful Program vs. Non-Participants				
	Females	Males	Minority	Non-Minority
Successful/Unsuccessful Program Participants	68.2%	76.5%	69.4%	75.7%
Non-Participants	59.1%	67.4%	67.7%	66.0%
Difference ^{1,2}	9.1% (5.9%)	9.1% (3.0%)*	1.6% (8.4%)	9.7% (2.8%)*
N for Participants / Non-Participants	132 \ 132	451 \ 451	62 \ 62	535 \ 535
Additional Students Retained within College	NA	41	NA	52

¹Average treatment effect among the treated, with standard error in parentheses

² * $p < 0.01$

Among the balanced dataset that uses propensity scores to match program participants to non-program participants, all subgroups' program participants have slightly higher within college second-fall retention rates compared to the non-participant rates. The difference between program participants and non-participants can only be attributed to program treatment effect for male and non-minority students. Table 8 shows there is a gain of 9.1 percentage points in within college second-fall retention for male participants and a 9.7 percentage point gain in within college second-fall retention for non-minority participants.

The average treatment effect can be applied to the total number of typical program participants to estimate the actual number of additional students retained within college because of the program. For instance, the 9.1 percentage point increase in within college second-fall retention for males resulted in approximately 41 ($.091 \times 451$) additional male

program participants from the FA10 to FA12 cohorts maintaining an EG major for their second fall semester. Similarly, about 52 (.097*535) additional non-minority program participants from the FA10 to FA12 cohorts maintain an EG major for their second fall semester because of their program participation.

3rd Fall Retention

Analyses of third-fall retention include EG students from the FA10 and FA11 cohorts.

Within University 3rd Fall Retention

Table 9 displays the within university third-fall retention rates for participants and non-participants by student subgroup prior to the propensity score adjustment.

Table 9.

Unadjusted within University 3 rd Fall Retention Rate Comparisons, Successful/Unsuccessful Program vs. Non-Participants				
	Females	Males	Minority	Non-Minority
Successful/Unsuccessful Program Participants	80.5%	81.5%	71.4%	82.6%
Non-Participants	83.2%	78.4%	75.0%	80.2%
Difference	-2.7%	3.2%	-3.6%	2.4%
N for Participants / Non-Participants	82 \ 143	276 \ 416	42 \ 68	316 \ 491

Similar to the observed rates for second-fall retention, male and non-minority program participants have slightly higher retention rates compared to their non-program peers; however, female and minority program participants have a lower third-fall retention rate compared to the non-participant female and minority students.

Table 10 displays the propensity score adjusted within university third-fall retention rates.

Table 10.

Propensity Score Adjusted within University 3 rd Fall Retention Rate Comparisons, Successful/Unsuccessful Program vs. Non-Participants				
	Females	Males	Minority	Non-Minority
Successful/Unsuccessful Program Participants	88.7%	81.5%	70.6%	82.5%
Non-Participants	77.4%	77.2%	67.6%	79.1%
Difference ^{1,2}	11.3% (6.7%)	4.2% (3.6%)	2.9% (11.4%)	3.3% (3.2%)
N for Participants / Non-Participants	62 \ 62	259 \ 259	34 \ 34	302 \ 302
Additional Students Retained within University	NA	NA	NA	NA

¹Average treatment effect among the treated, with standard error in parentheses

² * $p < 0.01$

Among the propensity score matched samples all program participants have slightly higher within university third-fall retention rates compared to non-program peers. However, none of these differences are large enough to be attributed to a treatment effect of the program. There is not a negative or positive impact of program participation on within university third-fall retention for any subgroup of students.

Within College 3rd Fall Retention

Table 11 displays the within college third-fall retention rates for participants and non-participants by student subgroup prior to the propensity score adjustment.

Table 11.

Unadjusted within College 3rd Fall Retention Rate Comparisons, Successful/Unsuccessful Program vs. Non-Participants				
	Females	Males	Minority	Non-Minority
Successful/Unsuccessful Program Participants	48.8%	60.5%	50.0%	58.9%
Non-Participants	47.6%	50.5%	42.6%	50.7%
Difference	1.2%	10.0%	7.4%	8.1%
N for Participants / Non-Participants	82 \ 143	276 \ 416	42 \ 68	316 \ 491

Similar to the observed within college second-fall retention rates, all participants have higher within college third-fall retention rates compared to non-participants.

Table 12 shows the third-fall retention rates among the propensity score adjusted data.

Table 12.

Propensity Score Adjusted within College 3rd Fall Retention Rate Comparisons, Successful/Unsuccessful Program vs. Non-Participants				
	Females	Males	Minority	Non-Minority
Successful/Unsuccessful Program Participants	54.8%	60.6%	47.1%	59.6%
Non-Participants	45.2%	48.3%	29.4%	49.7%
Difference ^{1,2}	9.7% (9.0%)	12.4% (4.4%)*	17.6% (11.8%)	9.9% (4.0%)
N for Participants / Non-Participants	62 \ 62	259 \ 259	34 \ 34	302 \ 302
Additional Students Retained within College	NA	32	NA	NA

¹Average treatment effect among the treated, with standard error in parentheses

² **p* < 0.01

All program participants have higher within college third-fall retention rates compared to the non-program rates. The difference between program participants and non-participants can only be attributed to program treatment effect for male students. Table 12 shows there is a gain of 12.4 percentage points in within college third-fall retention for male participants.

The average treatment effect can be applied to the total number of typical program participants to estimate the actual number of additional students retained within college because of the program. For instance, the 12.4 percentage point increase in within college third-fall retention for males resulted in approximately 32 (.124*259) additional male program participants from the FA10 and FA11 cohorts maintaining an EG major for their third fall semester.

GPA Comparisons among the Propensity Score Adjusted Data

Tables 13 and 14 provide the first-spring and second-fall end of term GPA comparisons between participants and non-participants from the FA10 through FA12 cohorts. Please note that the matched groups are no longer of equal size since not all students in the balanced data set persist until the end of their first-spring and second-fall semester and earn a term GPA. The students included in this analysis are statistically similar to one another from the propensity score matching; therefore, differences in GPA can be attributed to program participation rather than differences in demographics or academics.

Table 13.

First-Spring Term CSU GPA Comparisons, Among Propensity Score Adjusted Successful/Unsuccessful Program Participants vs. Non-Participants¹

	Females	Males	Minority	Non-Minority
Successful/Unsuccessful Program Participants	2.75	2.56	2.21	2.64
Non-Participants	2.84	2.53	2.49	2.62
Difference ^{2,3}	-0.09 (0.10)	0.02 (0.06)	-0.28 (0.17)	0.02 (0.06)
N for Participants / Non-Participants	125 \ 124	440 \ 431	60 \ 60	519 \ 512

¹Includes students who persist through the end of their first-spring semester among the propensity score matched samples

²Difference in means with standard error of difference in parentheses

³ **p* <0.01

Table 14.

Second-Fall Term CSU GPA Comparisons, Among Propensity Score Adjusted Successful/Unsuccessful Program Participants vs. Non-Participants¹

	Females	Males	Minority	Non-Minority
Successful/Unsuccessful Program Participants	2.62	2.72	2.40	2.72
Non-Participants	2.89	2.66	2.51	2.77
Difference ^{2,3}	-0.27 (0.16)	0.06 (0.08)	-0.11 (0.26)	-0.05 (0.08)
N for Participants / Non-Participants	69 \ 72	227 \ 269	30 \ 30	270 \ 308

¹Includes students who persist through the end of their second-fall semester among the propensity score matched samples

²Difference in means with standard error of difference in parentheses

³ **p* <0.01

Among the propensity score balanced data set there is not a significant difference in either term GPA for program participants compared to non-program participants. However, it is important to note that minority and female program participants have slightly lower GPA's compared to their non-participant peers at both time points and any positive differences in GPA for participants is very marginal (only a .06 or .02 difference).

Conclusions

In summary, program participation does not appear to have a significant impact, either positive or negative, on university retention (second or third year) or GPA (first-spring or second-fall) for engineering students. These results hold true for males, females, minorities and non-minorities.

The program does have a statistically significant positive impact for male and non-minority students on within college retention to the second fall. This impact translates to an average increase of approximately 52 additional students from the FA10 through FA12 cohorts staying in EG to the start of their second year. This positive treatment effect on within college retention does not hold for minority and female students. This statistically significant positive impact of program participation remains through the third fall semester for males but not for females, minorities or non-minorities.

Appendix

Appendix A.

Logistic Regression Coefficients for Engineering Success/Unsuccessful Program Participation Propensity Score¹

	Females	Males	Minority	Non-Minority	
	<i>b(se)</i> ⁵				
Minority	-0.35 (0.31)	-0.25 (0.21)			
First Generation	-0.05 (0.30)	-0.03 (0.17)	0.40 (0.36)	-0.10 (0.16)	
Pell Recipient	-0.11 (0.32)	-0.02 (0.18)	-0.20 (0.36)	0.01 (0.17)	
CCHE Index	-0.04 (0.02)	-0.03 (0.01)*	-0.02 (0.03)	-0.03 (0.01)*	
Math ACT Score ²	0.00 (0.05)	0.03 (0.02)	0.02 (0.07)	0.02 (0.02)	
CO Resident	-0.18 (0.26)	-0.25 (0.15)	0.03 (0.45)	-0.27 (0.13)	
Female			-0.20 (0.37)	-0.13 (0.15)	
Cohort Department/Major ³					
Chemical and Biological Engineering	-1.41 (0.44)*	-0.62 (0.27)	-1.39 (0.65)	-0.79 (0.24)*	
Civil and Environmental Engineering	-0.39 (0.36)	-0.55 (0.20)*	-0.48 (0.54)	-0.45 (0.19)	
Electrical and Computer Engineering	-0.85 (0.57)	-0.63 (0.23)*	-1.09 (0.62)	-0.62 (0.22)*	
Mechanical Engineering	-0.78 (0.40)	-0.60 (0.18)*	-0.72 (0.51)	-0.63 (0.17)*	
Biomedical Engineering ⁴	-0.67 (0.41)	0.24 (0.26)	-0.58 (0.60)	0.01 (0.23)	
Space Engineering or Engineering Science	-0.79 (0.81)	-0.30 (0.42)	0.65 (1.34)	-0.50 (0.39)	
	N	361	1127	184	1304
	Likelihood Ratio Chi-Squared, <i>df</i> = 12	25.73	38.57	10.39	47.36
	Pseudo R ²	0.053	0.0249	0.0425	0.0264

¹Includes first-time, full-time Engineering students from the FA10 through FA12 cohorts. This analysis excludes 26 of these students who do not have an index score.

²For students who do not have a Math ACT score their Math SAT score is converted to an ACT score. All students with an index score have a Math ACT or SAT score.

³All departments/majors are compared to Engineering Open Option majors

⁴Includes all specializations for Biomedical Engineering

⁵Cells display the regression coefficient with its standard error and an asterisk to indicate when $p < .01$

Appendix B.

Logistic Regression Coefficients for Engineering Success/Unsuccessful Program Participation Propensity Score¹

	Females	Males	Minority	Non-Minority
	<i>b(se)</i> ⁵			
Minority	-0.01 (0.42)	0.01 (0.27)		
First Generation	-0.18 (0.41)	-0.21 (0.23)	0.22 (0.45)	-0.26 (0.22)
Pell Recipient	0.29 (0.41)	-0.19 (0.23)	0.14 (0.46)	-0.15 (0.23)
CCHE Index	-0.05 (0.02)	-0.02 (0.01)	-0.05 (0.04)	-0.03 (0.01)
Math ACT Score ²	-0.02 (0.06)	-0.01 (0.03)	0.02 (0.08)	-0.01 (0.03)
CO Resident	-0.35 (0.33)	-0.28 (0.20)	-0.77 (0.59)	-0.32 (0.17)
Female			0.06 (0.54)	-0.15 (0.19)
Cohort Department/Major ³				
Chemical and Biological Engineering	-0.13 (0.59)	-0.52 (0.34)	-0.71 (0.92)	-0.52 (0.29)
Civil and Environmental Engineering	0.79 (0.55)	-0.69 (0.27)	0.75 (0.78)	-0.42 (0.24)
Electrical and Computer Engineering	0.11 (0.76)	-0.59 (0.29)	-0.20 (0.81)	-0.49 (0.29)
Mechanical Engineering	-0.03 (0.59)	-0.74 (0.23)*	0.19 (0.73)	-0.73 (0.22)*
Biomedical Engineering ⁴	0.46 (0.65)	-0.02 (0.35)	0.35 (0.93)	-0.01 (0.32)
Space Engineering or Engineering Science	0.06 (1.03)	-0.35 (0.54)		-0.35 (0.47)
N	225	692	110	807
Likelihood Ratio Chi-Squared, <i>df</i> = 12	19.4	24.27	8.83	30.59
Pseudo R ²	0.0657	0.0261	0.0604	0.0283

¹Includes first-time, full-time Engineering students from the FA10 and FA11 cohorts. This analysis excludes 16 of these students who do not have an index score.

²For students who do not have a Math ACT score their Math SAT score is converted to an ACT score. All students with an index score have a Math ACT or SAT score.

³All departments/majors are compared to Engineering Open Option majors

⁴Includes all specializations for Biomedical Engineering

⁵Cells display the regression coefficient with its standard error and an asterisk to indicate when $p < .01$